NASA TECH BRIEF

Midcourse Maneuver Operations Program

The problem:

To develop a method which is capable of establishing the existence of maneuvers which satisfy spacecraft and associated constraints, and which possess the capability to explore alternate trajectories in the event that some out-of-tolerance condition forces a change in plans, and to code the maneuvers into commands acceptable to the spacecraft.

The solution:

The Midcourse Maneuver Operations Program (MMOP) was specifically designed to compute the required velocity change to correct a spacecraft trajectory. Various general classes of constraints are examined, and the required velocity change is adjusted, if necessary, to avoid violation of constraints. Otherwise the program evaluates consequences of the constraint violation and computes a maneuver which represents a least violation.

How it's done:

The MMOP serves two primary purposes. It performs calculations which enable the operations personnel to select the most advantageous maneuver after the orbit achieved by the spacecraft is known. If the mission proceeds according to plan, the selection of the maneuver will be straightforward; otherwise, an appreciable quantity of trajectory and performance information must be rapidly analyzed under operational pressure to ensure that the capabilities of the spacecraft are used intelligently. The spacecraft can still gather significant scientific information even if it follows a trajectory different from nominal. Operations personnel must make appropriate guidance decisions as long as there is any chance of obtaining useful scientific or engineering information. The program also codes the commands that will make the spacecraft perform the desired maneuver. The midcourse maneuver requires three 26-bit stored quantitative commands, which are transmitted to the spacecraft and stored until receipt of the real-time direct command that initiates the sequence.

In computing the maneuver, various practical constraints imposed by the limitations of the spacecraft have to be considered. Accordingly, the program consists of two subprograms: (1) a set of drivers for the trajectory program, and (2) decision routines which are used to compute and code the desired maneuvers.

In computing and executing the midcourse maneuver, the spacecraft is first tracked from launch and a definitive orbit determination is made. The midcourse velocity impulse required to modify the trajectory of the spacecraft so that it flies by the target planet in an acceptable way and at a favorable time is then computed. The velocity impulse vector is converted to the appropriate coordinates: pitch turn angle, roll turn angle, and magnitude of impulse. These values are then converted to the binary coded form acceptable to the spacecraft. The three stored commands are transmitted, properly coded, to the appropriate deep space instrumentation facility where they are verified; and the direct command, EXECUTE MIDCOURSE MANEUVER, is transmitted. The spacecraft executes the pitch and roll turns, the midcourse motor is ignited, and, after completing the maneuver, the spacecraft returns to the cruise mode, orienting itself through Sun and Canopus sensors.

The inputs to the operations program can be conveniently divided into three classifications: (1) the basic inputs from the tracking program are the best estimates of the six injection coordinates and the injection time; (2) the prelaunch input generally consists of items which can be considered constants of

(continued overleaf)

the spacecraft system and thus not subject to variation during either nominal or unexpected operating conditions; (3) items in the post-launch input are items which are subject to change during the mission and control commands for the program. The input from the tracking program and the post launch input will be read in during operations. The prelaunch input will be the nominal values unless changes have been made. The capability to enter all inputs will be provided for nonoperational use of the program, which is expected to be extensive before each flight.

There are three operational options which will generally be used before selecting the midcourse. All three operational options require access to the prelaunch input, and the inputs from the tracking program. The first option is the Midcourse Maneuver Program which is the only option that has the capability of computing a maneuver.

Notes:

1. The program is written partly in FORTRAN II language and partly in FAP language for use on the IBM 7094 II machine.
2. The program is of use to anyone working on a space project to perform near-planet measurements, where it may be necessary to correct the initial trajectory of the spacecraft with a midcourse maneuver in order to ensure success of the mission.
3. Inquiries regarding this innovation may be directed to:

   COSMIC
   Computer Center
   University of Georgia
   Athens, Georgia 30601
   Reference: B69-10105

Patent status:

No patent action is contemplated by NASA.

Source: Robert T. Mitchell, Harold J. Gordon, R. L. Hamburg, D. Pass, and Donald R. Royer
Jet Propulsion Laboratory
(NPO-10735)